MULTI-CRITERIA MEASUREMENT OF AGRI-ENVIRONMENTAL PERFORMANCE IN EUROPEAN UNION COUNTRIES

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A R T I C L E I N F O

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A B S T R A C T

The purpose of the paper is to assess the agri-environmental situation in the European Union at the national level. To realize that goal, a multi-criteria analysis of indicators from the official European database was used. The results of the ranking show that Portugal, Estonia, and Ireland are at the top according to agri-environmental performance, while the worst ranked countries are Malta, the Netherlands, Slovenia, and Cyprus. The common agricultural policy of the European Union must be designed to improve the position of certain countries, based on the experience and sustainable agricultural practices of the leading countries in this area, considering the obtained research results. This study can contribute to the creators of agri-environmental policies in the preparation of the future strategy of the agricultural development of the European Union countries.

Introduction

As part of the assessment of the sustainable development of society, environmental and agricultural sustainability have a special place. The sustainability of agriculture relies

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heavily on environmental sustainability (Mukherjee, 2022). In fact, agriculture is an activity, which, unlike others, depends significantly on natural and climatic factors. But, at the same time, it exerts a significant impact on the environment (negative externalities), bearing in mind the reliance on land as a basic natural resource in agricultural production. According to the latest data from the World Bank (2021), agricultural land makes up 40.76% of the total land of the European Union. Lal (2009) argues that ecosystem degradation due to inadequate agricultural practices can be devastating to all of humanity. The following trends are characteristic of agriculture: (i) increasing use of pesticides that pollutes the soil, (ii) accelerated conversion of forest land into agricultural land, which affects soil erosion, (iii) large emissions of ammonia, and (iv) agricultural intensification. All this calls into question the possibility of agricultural development in the future and disrupts the entire ecosystem to a certain extent. That is why Volkov et al. (2020) in the study emphasize that agricultural performance must always be viewed together with environmental indicators. Their study showed that the newer member states of the European Union achieve better agri-environmental performance compared to the members that joined earlier.

Although it does not have a significant contribution to the gross domestic product, agriculture is important because it ensures food security and poverty reduction; affects the satisfaction of basic human needs, as well as human health (considering food quality and the impact of agricultural activities and practices on natural resources and the environment) (Renner et al., 2020; Streimikiene, & Mikalauskiene, 2023). In addition, it is expected that this sector will gain importance, bearing in mind the forecast of further increase in food prices. Agriculture must provide enough food for the growing population, but without harming the quality of the environment (water, soil, air, etc.), which is the idea of sustainable development of this economic activity (Skaf et al., 2019). The increasing number of studies on this topic testifies to the significant interest of the scientific community in the problem of sustainability, quantifying the sustainable development of agriculture, as well as the impact of the agricultural sector on the environment (Talukder, Blay-Palmer, & Hipel, 2020; Streimikiene, & Mikalauskiene, 2023). Therefore, our determination is to investigate the achieved level of development of agri-environmental performance in the countries of the European Union. This economic integration directs significant resources to agriculture, its protection from foreign competition, as well as for strengthening the position of farmers. Also, the Common Agricultural Policy of the European Union influences the greening of the agricultural sector and the reduction of negative effects on the environment (Rudnicki et al., 2023), especially due to high energy consumption and high greenhouse gas emissions (Cheba et al., 2022). All reforms of the European Union’s Common Agricultural Policy had measures to prevent negative effects of agricultural production on the environment (Salvan et al., 2022). Considering the amount of energy consumed by agriculture, it is necessary to reduce consumption due to at least two reasons: (i) high energy dependence of European countries, and (ii) negative consequences on environmental pollution.

In recent years, global society has faced economic, energy, political and health crises. This also influenced the transformation of agricultural practices to minimize the negative impact on the environment (Cheba et al., 2022). Namiotko et al. (2022) point out that the deterioration of agri-environmental indicators is one of the important aspects of these crises, so in their work they apply TOPSIS, EDAS and SAW methods of multi-criteria analysis for European countries to find and overcome this situation. With this objective in mind, they analyse seven agri-environmental indicators: ammonia emissions from agriculture, areas of intensive agriculture, average organic carbon content in arable land, surface water quality, groundwater quality, the farmland birds index, and the favourable conservation status of agricultural habitats. Marković et al. (2023) state that intensive irrigation, the use of chemicals and the disruption of biodiversity due to monoculture production are the key issues of concern. That is why the evaluation of environmental sustainability of agriculture is important. Multi-criteria decision making is particularly prevalent in the field of sustainable development (Bartzas, & Komnitsas, 2020; Castillo-Díaz et al., 2023), bearing in mind the multidimensionality of the research problem and the complexity of data aggregation. Observing agri-environmental performance using multi-criteria decision-making methods has been the preoccupation of researchers, especially since 2016 (Gürlük, & Uzel, 2016; Gómez-Limón, Arriaza, & Guerrero-Baena, 2020; Cicciù, Schramm, & Schramm, 2022). Most of this research apply criteria such as enhancing or protecting biodiversity, improving habitat diversity, minimizing soil erosion, promoting soil fertility, improving soil and water quality, reducing water extraction, optimizing energy balance, maximizing the economic value of agricultural production, increasing the efficiency of fertilizer and pesticide use, and/or reducing total agricultural emissions. Recent research used the following techniques: Principal Component Analysis, Data Development Analysis, and the DEXiPM (Cicciù, Schramm, & Schramm, 2022). In this paper, the authors opted for the MOORA (Multi-Objective Optimization by Ratio Analysis) method, which until now (according to the literature review) has not been used in the ranking of European Union countries according to agri-environmental status, and it is ideal for conflicting criteria that exist in this case. In addition to the highlighted originality of the study, the justification for the research lies in the fact that there is still no unified view of the coverage of agri-environmental indicators that would constitute a single, composite index. The basic research question of this paper is: Which countries of the European Union represent leaders in terms of agri-environmental performance, and which, on the other hand, should significantly improve their prospects for the realization of ecologically acceptable agriculture?

The study consists of several standard parts. After the introduction, the analysis material (indicators, data sources, definitions) is presented in detail, the weighting method is described, as well as the data aggregation tool (section Materials and methods). Then, the research results are presented in tabular and graphical form. In this unified section (Results and Discussion), an effort will be made to review and evaluate the current situation in the countries of the European Union based on the obtained composite indicators of agri-environmental performance. In the last section (Conclusions), final considerations and limitations of the research will be stated, and recommendations to other authors for future research on this topic will be highlighted.

Materials and methods

Multi-criteria decision-making implies several stages. The first step in creating a composite index is the choice of indicators. Carefully selected indicators are essential for the later decision-making by sustainable development policy makers (Krstić, Milenović, & Rađenović, 2021). The authors selected seven indicators from the database of the European Commission (Eurostat), from the segment related to agri-environmental indicators. These are the attributes that will be used in the multi-criteria model. The choice was conditioned by the level of observation (national level), the availability of data, as well as their relevance (significance) based on a thorough review of the literature. Thus, the following indicators of agri-environmental performance were reached (European Commission, 2024):

1. *Area under organic farming (percentage of the total used agricultural land),*
2. *Final energy consumption by agriculture/forestry (per hectare of utilised agricultural area),*
3. *Permanent grassland (percentage of the total used agricultural land),*
4. *Energy productivity (EUR per kilogram of oil equivalent),*
5. *Ammonia emissions from agriculture (kilograms per hectare),*
6. *Greenhouse gas emissions from agriculture (in percentage), and*
7. *Estimated soil loss by water erosion (tonnes per hectare).*

Table 1 provides a description of the indicators, the unit of measure for each of them, as well as information on the year to which the data refer (the most recent data according to the Eurostat database).

Table 1. Display and description of the indicators/criteria used in the model

Criteria	Year (last available year)	Unit of measurement	Description
Area under organic farming (C1)	(2021), except for Greece and Austria (2020)	%	Areas under organic production (crop and livestock production) calculated as a percentage of the total used agricultural land
Final energy consumption by agriculture/forestry (C2)	(2022)	consumption per hectare	Final energy consumption by agriculture/ forestry per hectare of utilized agricultural area, which represents the sum of all types of energy supplied to the agricultural sector
Permanent grassland (C3)	(2016)	%	The share of permanent grasslands in the total used agricultural area

Criteria	Year (last available year)	Unit of measurement	Description
Energy productivity (C4)	(2022)	EUR per kilogram	It is calculated as the amount of economic production (in euros) per unit of gross available energy
Ammonia emissions from agriculture (C5)	(2021)	kg per hectare	Agriculture is the sector that predominantly emits ammonia and thus affects air pollution. This indicator measures the amount of ammonia emissions from agriculture per hectare of the total used area under agriculture
Greenhouse gas emissions from agriculture (C6)	(2022)	%	Percentage of emissions coming from agricultural activities
Estimated soil loss by water erosion (C7)	(2016)	tonnes per hectare	Estimated soil erosion caused by water, expressed in tons per hectare. Both agricultural areas and natural grassland are included in the calculation of this indicator

Source: Authors' representation based on European Commission definitions, 2024

Three indicators are revenue-type criteria (*Area under organic farming, Permanent grassland,* and *Energy productivity*), while the remaining four indicators are cost-related criteria (*Final energy consumption by agriculture/forestry, Ammonia emissions from agriculture, Greenhouse gas emissions from agriculture,* and *Estimated soil loss by water erosion*).

Before building the composite index, it is necessary to define the method of determining the weighting coefficients. As a method of weighting, the method of equal weighting coefficients was applied in the paper. Based on the existing shortcomings of subjective methods, the paper uses the method of equal weighting coefficients, which gives equal relative importance to each indicator (when creating a composite index). In this way, the subjectivity of decision-makers and the possible favouring of some indicators were avoided, and on the other hand, the task was significantly simplified, bearing in mind the different preferences of stakeholders (interested parties) at the macro or micro level (Hagerty, & Land, 2007).

In aggregating data, the authors chose one of the newer multi-criteria methods that has not been applied in the assessment of agri-environmental sustainability - the MOORA (Multi-Objective Optimization based on Ratio Analysis) method. The MOORA method is selected due to its ability to normalize and compare criteria that may have different units of measurement, making it particularly suitable for complex decision-making scenarios (Brauers, & Zavadskas, 2006). Additionally, the MOORA method does not require complex mathematical models, allowing decision-makers to easily apply it without extensive computational resources (Stanujkic et al., 2012). In the process of obtaining the value of the composite index, the authors followed the steps described below and manually arrived at the final results. Scientists use this tool when it is necessary to reduce various conflicting indicators to a single measure and to rank alternatives (Filipe, & Caleiro, 2020). By simultaneous optimization of several criteria, an aggregate indicator is obtained, in this case, the index of agri-environmental performance of the countries of the European Union. The MOORA method usually involves the following procedures for calculating the composite index and ranking the alternatives (Brauers, & Zavadskas, 2006; Gadakh, Shinde, & Khemnar., 2013; Madić, Radovanović, & Petković, 2015; Marjanović, Rađenović, & Marković, 2019):

Step 1. Creating a decision matrix $X_S = [x_{ij}] X_S = [x_{ij}]$,

where:

x_{ij} – the value of the alternative i according to the criterion j,

$i = 1, 2, \ldots, m$ (number of alternatives) and $j = 1, 2, \ldots, n$ (number of criteria).

Step 2. Determining the normalized decision matrix, where x^*_{ij} are normalized values:

$$x^*_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}$$

Step 3. Optimization of the multi-criteria problem, where the normalized values of the revenue criteria (multiplied by the weighting coefficients) are added, while the normalized values of the cost criteria (multiplied by the weighting coefficients) are subtracted:

$$y_{ij} = \sum_{j=1}^{g} w_j x^*_{ij} - \sum_{j=g+1}^{n-g} w_j x^*_{ij}$$

where:

g (number of revenue criteria), n-g (number of cost criteria), and w_j - the weight coefficients. The values of the normalized decision matrix are multiplied by the weighted coefficients to form a preference-normalized decision matrix. In this paper equal weighting approach has been applied as one of the objective approaches. This approach is commonly applied in situations where input from the decision-maker is unavailable or when insufficient information exists to determine the relative importance of criteria (Jahan et al., 2012). Equal weighting assumes that all criteria hold equal importance, eliminating the need for subjective judgments or complex weighting schemes, which can sometimes introduce bias. The equal weights can be calculated using the following equation:

$$w_j = \frac{1}{n}$$

where n is the number of criteria. Therefore, in the following analysis each indicator will have a weight coefficient of 0.142857. In other words, the sum of the weighted values is equal to the one.

Step 4. Ranking of the alternatives (in descending order of value), with the best being the one with the highest value y_{ij}. The value of the composite index can be both positive and negative, depending on whether revenue or cost criteria dominate. Unlike methods that generate results on a specific scale (such as from 0 to 1), the MOORA method produces results that depend on the specific data and context of the decision problem. The range of results is influenced by the number of criteria, the distribution of the data, and the weighting factors. While the results are typically within the [-1, 1] interval, the MOORA method can produce scores that vary beyond this range (Stanujkic et al., 2012). Therefore, the scores within the specific context of the decision-making problem should be analysed.

Results and Discussions

First, Table 2 shows the descriptive statistics of the selected indicators. One of the indispensable indicators in the evaluation of the environmental performance of agriculture is organic production. The percentage of areas under organic production is the highest in Austria, while the lowest is in Malta. The data argue that the highest energy consumption per hectare was recorded in the Netherlands' agriculture, while the lowest consumption was in Bulgaria. The latest available data shows that the percentage of permanent grassland is highest in Ireland, while it is almost non-existent in Malta. They are particularly important from the standpoint of biodiversity conservation. Ireland achieves the highest energy productivity, while Bulgaria achieves the lowest. When looking at ammonia emissions from agriculture, the worst situation is in Malta, while farmers in Latvia realise the lowest ammonia emissions. At the level of the European Union, according to data for 2021, over 90% of ammonia emissions on average originate from agriculture (European Commission, 2024), and this percentage is the highest in Ireland (99.2%), while the lowest is in Germany (82%), as the most industrialized country in the European Union. One of the leading causes of climate change, i.e. of global warming is ammonia emissions, so this indicator is almost always used in assessing the impact of agriculture on the environment (Shakoor et al., 2021). These emissions are caused by the production of methane and nitrogen oxides, and uncontrolled application of fertilizers, which may affect the sustainability of agricultural production in the future (Marković et al., 2023). Greenhouse gas emissions from agriculture are the highest in Ireland, while they are the lowest in Malta. Finally, inadequate water management practices in agriculture cause a significant reduction in soil quality and soil erosion. It is one of the most common types of soil degradation in the European Union, so it is a common element when looking at agri-environmental performance (Panagos et al., 2020; European Commission, 2024). Estimated soil loss by water erosion is most present in Slovenia, while the Netherlands shows the most favourable value.

The results of descriptive statistics indicate that the highest average deviations from the mean value are for the indicator *Final energy consumption by agriculture/forestry per hectare of utilized agricultural area*, so at the same time there are also the biggest differences between the countries of the European Union when it comes to the same indicator.

Table 2. Descriptive data statistics

Criteria	Maximum	Minimum	Mean	Std. deviation	Coefficient of variation
Area under organic farming	25.69	0.61	10.57	6.58	62.25
Final energy consumption by agriculture/forestry per hectare of utilised agricultural area	1627.00	38.49	275.24	399.44	145.12
Permanent grassland	90.60	0.00	31.09	19.25	61.92
Energy productivity	26.77	2.53	8.65	4.92	56.88
Ammonia emissions from agriculture	120.40	6.80	25.44	23.10	90.80
Greenhouse gas emissions from agriculture	35.30	3.30	12.10	6.96	57.52
Estimated soil loss by water erosion	14.80	0.30	3.29	3.29	100.00

Source: Calculation of authors based on European Commission data, 2024

Table 3 shows the ranking of the countries of the European Union and the values of the composite indices calculated using the MOORA method. Portugal, Estonia, and Ireland stand out at the top of the list, as countries that, according to the results of the research, achieve the best agri-environmental results. On the other hand, Malta has the weakest agri-environmental performance. Along with Malta, the Netherlands, Slovenia, and Cyprus achieve rather poor results in this regard. Fourteen countries of the European Union have positive values of the aggregate indices (left side of Table 3), while in the remaining thirteen countries, cost criteria dominate over revenue ones (right side of Table 3), which results in negative values of the obtained indices.

Table 3. Values of composite indices of agri-environmental performance and ranking of European Union countries

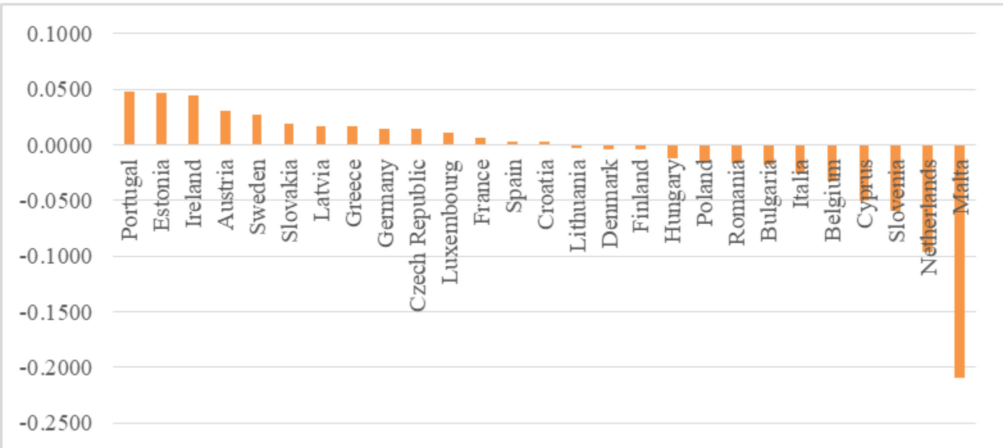
Country	Composite index	Rank	Country	Composite index	Rank
Portugal	0.0479	1	Lithuania	-0.0031	15
Estonia	0.0473	2	Denmark	-0.0036	16
Ireland	0.0448	3	Finland	-0.0044	17
Austria	0.0309	4	Hungary	-0.0118	18
Sweden	0.0267	5	Poland	-0.0154	19
Slovakia	0.0195	6	Romania	-0.0165	20
Latvia	0.0168	7	Bulgaria	-0.0178	21
Greece	0.0163	8	Italia	-0.0254	22
Germany	0.0146	9	Belgium	-0.0323	23
Czech Republic	0.0146	10	Cyprus	-0.0497	24

Country	Composite index	Rank	Country	Composite index	Rank
Luxembourg	0.0114	11	Slovenia	-0.0593	25
France	0.0061	12	Netherlands	-0.0964	26
Spain	0.0034	13	Malta	-0.2091	27
Croatia	0.0032	14			

Source: Calculation of authors based on European Commission data, 2024

Figure 1 shows the performance index values by country. It is concluded that there are no big differences between the countries of the European Union when looking at the calculated aggregate indicator of agri-environmental performance. This stems from the fact that there are certain countries that are very well positioned according to some indicators, while according to other indicators they have poor results at the level of the European Union. For example, Austria is the leader in terms of areas under organic production, while it is at the very bottom when it comes to the indicator related to soil erosion. Similarly, although Malta is the worst ranked country, it shows the best values for permanent grassland and greenhouse gas emissions. Furthermore, Ireland is at the top in all indicators except for area under organic production and greenhouse gas emissions.

Figure 1. Composite indices of agri-environmental indicators in European Union countries

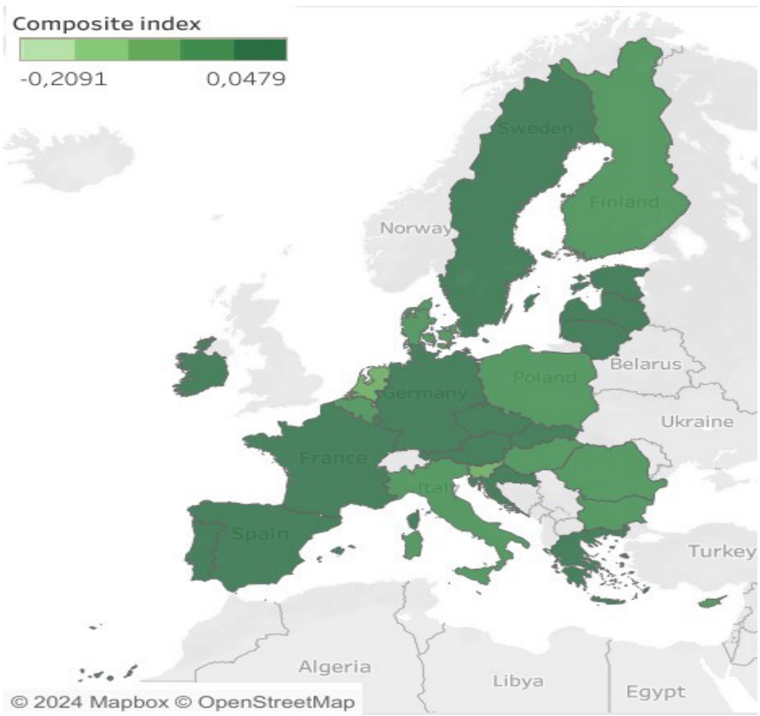


Source: Authors' calculations

In order to improve the placement of certain countries and improve agri-environmental sustainability at the level of the European Union, it is necessary to insist on the concept of organic agriculture and the transition to a circular model of agricultural production. Organic agriculture has been proven as the basic form of sustainable agriculture (Marković et al., 2023). It is one of the ways to ensure high-quality, healthy food, the production of which will have minimal negative effects on the environment due to reduced use of pesticides, herbicides, fertilizers (Rouyendegh, & Savalan, 2022). In this way, soil fertility and biodiversity will be preserved, and farmers can earn solid incomes, bearing in mind the high price of organic products. Another way to build ecological agriculture can be the application of modern circular solutions (Silvestri et al., 2022), primarily in waste management from agriculture (Lombardi, & Todella, 2023). Circular models in agriculture are aimed at reducing the consumption of energy and other resources, as well as reducing waste and negative emissions, which affects many agri-environmental indicators and can lead to the fulfilment of the goals of the 2030 Agenda (Castillo-Díaz et al., 2023). Raising awareness of the strong cause-and-effect relationships between agriculture and the environment and their joint impact on the quality of life of people in every sense must be a priority (Šebek, 2020).

Finally, in Figure 2, the position of the countries of the European Union is clearly illustrated through the maps. Countries with a better state of agri-environmental performance have a darker colour, in contrast to the worse ones, which are assigned a lighter shade.

Figure 2. Graphical presentation of the composite indices' values of agri-environmental indicators of the European Union countries



Source: Authors' calculations. The map was generated using Tableau Public 2023.1

Conclusions

The study formed (developed) a model (framework) for evaluating agri-environmental performance at the national level. In this way, it is easy to follow the movement of the obtained composite index over time and compare performance indices among different countries. Accordingly, policy makers can take appropriate decisions. The results of the research represent an added value for the future definition of practices, programs, and redesign of the Common Agrarian Policy of this economic integration. Emphasis must be placed on the use of environmentally friendly technologies and the use of renewable resources to preserve natural capital and slow down climate change. Research limitations are determined by the choice of indicators, the choice of multi-criteria decision-making methods, as well as the availability of data. Authors of future research could have a modified set of agri-environmental performance indicators (compared to those proposed by the authors), apply other method of analysis, as well as use updated data as soon as they are available in the database used in this study. Thus, this study can be used for comparison with results obtained in some other way. It is necessary for official databases to be supplemented with indicators of biodiversity, as well as consumption and pollution of water due to agricultural production.

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Conflict of interests

The authors declare no conflict of interest.

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Appendix

Table A1. Normalized decision matrix

	C1	C2	C3	C4	C5	C6	C7
Belgium	0.1163	0.2320	0.1868	0.1403	0.2541	0.1164	0.0668
Bulgaria	0.0266	0.0155	0.1360	0.0491	0.0429	0.1399	0.1378
Czech Republic	0.2417	0.0698	0.1444	0.0915	0.0988	0.0984	0.1086
Denmark	0.1800	0.0856	0.0455	0.3448	0.1288	0.3602	0.0209
Germany	0.1500	0.0883	0.1487	0.2067	0.1440	0.0956	0.0752
Estonia	0.3570	0.0394	0.1619	0.0814	0.0520	0.1566	0.0209
Ireland	0.0311	0.0291	0.4793	0.5200	0.1610	0.4891	0.0376
Greece	0.1577	0.0204	0.2159	0.1616	0.0616	0.1344	0.2047
Spain	0.1677	0.0427	0.1735	0.1799	0.1062	0.1566	0.1921
France	0.1503	0.0605	0.1635	0.1997	0.0994	0.2148	0.0961
Croatia	0.1284	0.0661	0.2058	0.1305	0.1000	0.1302	0.1462
Italia	0.2616	0.0905	0.1360	0.2154	0.1395	0.1011	0.4595
Cyprus	0.0999	0.1380	0.0063	0.1706	0.2632	0.0776	0.1462
Latvia	0.2384	0.0394	0.1735	0.1078	0.0384	0.2951	0.0292
Lithuania	0.1385	0.0174	0.1391	0.1140	0.0700	0.2923	0.0334
Luxembourg	0.0807	0.0846	0.2719	0.2856	0.2400	0.0914	0.1420
Hungary	0.0903	0.0473	0.0783	0.1047	0.0785	0.1427	0.0877
Malta	0.0095	0.6347	0.0000	0.0835	0.6800	0.0457	0.1963
Netherlands	0.0656	0.6537	0.2148	0.1913	0.3264	0.1538	0.0125
Austria	0.3993	0.0790	0.2492	0.2065	0.1327	0.1344	0.2924
Poland	0.0587	0.0939	0.1164	0.1024	0.1084	0.1205	0.0627
Portugal	0.3001	0.0404	0.2725	0.1659	0.0740	0.1593	0.1295
Romania	0.0687	0.0176	0.1799	0.1171	0.0610	0.2272	0.1754
Slovenia	0.1680	0.0620	0.3090	0.1406	0.2016	0.1510	0.6182
Slovakia	0.2090	0.0269	0.1471	0.1049	0.0666	0.0720	0.1587
Finland	0.2246	0.1241	0.0063	0.1239	0.0678	0.1773	0.0167
Sweden	0.3139	0.0870	0.0794	0.1970	0.0830	0.1912	0.0418

Table A2. Preference-normalized decision matrix

	C1	C2	C3	C4	C5	C6	C7
Weights	*0.1429*	*0.1429*	*0.1429*	*0.1429*	*0.1429*	*0.1429*	*0.1429*
Belgium	0.0166	0.0331	0.0267	0.0200	0.0363	0.0166	0.0095
Bulgaria	0.0038	0.0022	0.0194	0.0070	0.0061	0.0200	0.0197
Czech Republic	0.0345	0.0100	0.0206	0.0131	0.0141	0.0141	0.0155
Denmark	0.0257	0.0122	0.0065	0.0493	0.0184	0.0515	0.0030
Germany	0.0214	0.0126	0.0212	0.0295	0.0206	0.0137	0.0107
Estonia	0.0510	0.0056	0.0231	0.0116	0.0074	0.0224	0.0030
Ireland	0.0044	0.0042	0.0685	0.0743	0.0230	0.0699	0.0054
Greece	0.0225	0.0029	0.0308	0.0231	0.0088	0.0192	0.0292
Spain	0.0240	0.0061	0.0248	0.0257	0.0152	0.0224	0.0274
France	0.0215	0.0086	0.0234	0.0285	0.0142	0.0307	0.0137
Croatia	0.0183	0.0094	0.0294	0.0186	0.0143	0.0186	0.0209
Italia	0.0374	0.0129	0.0194	0.0308	0.0199	0.0144	0.0656
Cyprus	0.0143	0.0197	0.0009	0.0244	0.0376	0.0111	0.0209
Latvia	0.0341	0.0056	0.0248	0.0154	0.0055	0.0422	0.0042
Lithuania	0.0198	0.0025	0.0199	0.0163	0.0100	0.0418	0.0048
Luxembourg	0.0115	0.0121	0.0388	0.0408	0.0343	0.0131	0.0203
Hungary	0.0129	0.0068	0.0112	0.0150	0.0112	0.0204	0.0125
Malta	0.0014	0.0907	0.0000	0.0119	0.0971	0.0065	0.0280
Netherlands	0.0094	0.0934	0.0307	0.0273	0.0466	0.0220	0.0018
Austria	0.0570	0.0113	0.0356	0.0295	0.0190	0.0192	0.0418
Poland	0.0084	0.0134	0.0166	0.0146	0.0155	0.0172	0.0090
Portugal	0.0429	0.0058	0.0389	0.0237	0.0106	0.0228	0.0185
Romania	0.0098	0.0025	0.0257	0.0167	0.0087	0.0325	0.0251
Slovenia	0.0240	0.0089	0.0441	0.0201	0.0288	0.0216	0.0883
Slovakia	0.0299	0.0038	0.0210	0.0150	0.0095	0.0103	0.0227
Finland	0.0321	0.0177	0.0009	0.0177	0.0097	0.0253	0.0024
Sweden	0.0448	0.0124	0.0113	0.0281	0.0119	0.0273	0.0060

Table A3. Calculation of MOORA score

Country	Sum of normalized criteria values		MOORA score (difference)
	Revenue criteria	Cost criteria	
Belgium	0.0633	0.0956	-0.0323
Bulgaria	0.0302	0.0480	-0.0178
Czech Republic	0.0682	0.0537	0.0146
Denmark	0.0815	0.0851	-0.0036
Germany	0.0722	0.0576	0.0146
Estonia	0.0858	0.0384	0.0473
Ireland	0.1472	0.1024	0.0448
Greece	0.0765	0.0601	0.0163
Spain	0.0744	0.0711	0.0034
France	0.0734	0.0672	0.0061
Croatia	0.0664	0.0632	0.0032
Italia	0.0876	0.1130	-0.0254
Cyprus	0.0395	0.0893	-0.0497
Latvia	0.0742	0.0574	0.0168
Lithuania	0.0559	0.0590	-0.0031
Luxembourg	0.0912	0.0797	0.0114
Hungary	0.0390	0.0509	-0.0118
Malta	0.0133	0.2224	-0.2091
Netherlands	0.0674	0.1638	-0.0964
Austria	0.1221	0.0912	0.0309
Poland	0.0396	0.0551	-0.0154
Portugal	0.1055	0.0576	0.0479
Romania	0.0522	0.0687	-0.0165
Slovenia	0.0882	0.1475	-0.0593
Slovakia	0.0659	0.0463	0.0195
Finland	0.0507	0.0551	-0.0044
Sweden	0.0843	0.0576	0.0267